U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF PLANT INDUSTRY—BULLETIN No. 52.
B. T. GALLOWAY, *Chief of Bureau.*

WITHER-TIP AND OTHER DISEASES OF CITROUS TREES AND FRUITS

CAUSED BY

COLLETOTRICHUM GLŒOSPORIOIDES.

BY

P. H. ROLFS,
PATHOLOGIST IN CHARGE OF SUBTROPICAL LABORATORY.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

ISSUED MARCH 3, 1904.

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BULLETINS OF THE BUREAU OF PLANT INDUSTRY.

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FIG. 1. ANTHRACNOSE OF LIME.

FIG. 2. WITHER-TIP OF LIME.

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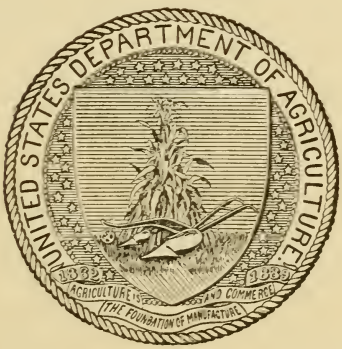

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BUREAU OF PLANT INDUSTRY.

B. T. Galloway, *Chief.*

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., October 8, 1903.

Sir: I have the honor to transmit herewith a paper entitled "Wither-Tip and Other Diseases of Citrous Trees and Fruits Caused by Colletotrichum Glœosporioides," and respectfully recommend that it be published as Bulletin No. 52 of the series of this Bureau.

This paper was prepared by Mr. P. H. Rolfs, Pathologist in Charge of the Subtropical Laboratory of this Bureau, under the direction of the Pathologist and Physiologist, by whom the paper was submitted with a view to publication. The accompanying six plates, three of which are colored, are believed to be necessary for a complete understanding of the subject-matter under discussion.

Respectfully,

B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

PREFACE.

The diseases of citrous fruits described in this report have caused within the past four or five years considerable loss to the cultivators of these fruits, especially in the more humid regions. A fungus (*Colletotrichum glœosporioides* Penzig) has long been known as the cause of a disease on orange, pomelo, and lemon twigs, commonly called "wither-tip," and the same fungus causes a serious disease of the leaves, known as "leaf-spot," on these and other citrous trees. Mr. Rolfs has now demonstrated that anthracnose of lime blossoms and young fruits and of lime and lemon twigs, "spot" of ripe lemons, and "canker" of limes are all caused by this same fungus. A knowledge of this fact should be of great value to citrus growers in combating these diseases.

By proper pruning and fungicidal treatment, as recommended in this report, all of these troubles may be easily prevented or controlled.

Thanks are due to Mr. F. D. Waite, general manager of the Manatee Lemon Company, for many courtesies shown during the progress of these investigations.

ALBERT F. WOODS.
Pathologist and Physiologist.

OFFICE OF VEGETABLE PATHOLOGICAL
AND PHYSIOLOGICAL INVESTIGATIONS,
Washington, D. C., October 3, 1903.

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WITHER-TIP AND OTHER DISEASES OF CITROUS TREES AND FRUITS CAUSED BY COLLETOTRICHUM GLŒOSPORIOIDES.

INTRODUCTION.

The group of diseases discussed in this bulletin was unknown in Florida until a comparatively recent time. At first recorded as of merely passing interest, the attacks of the fungus *Colletotrichum glœosporioides* have since increased in severity until they are now assuming serious proportions in various citrous crops. The amount of damage done by lemon-spot is often sufficient to eliminate the profits of the shipments in which the disease occurs. As wither-tip it repeatedly kills back the new growth of young trees until their vitality is exhausted. On large trees the small twigs are cut off, thus preventing the tree from producing the bloom necessary to set a heavy crop. As anthracnose and canker of lime it has caused an almost total destruction of the crop where the disease has gained a foothold.

The fact that the attack of this fungus manifests itself in various diseases has greatly complicated the work and added immensely to the labor of demonstrating its identity. The results of the miscroscopic work indicated that these various diseases—wither-tip, leaf-spot, lemon-spot, canker, and anthracnose—were produced by one species of fungus. It remained for cross inoculation with pure cultures to confirm this supposition. In most cases these cross inoculations took readily, while in others it was difficult to induce the fungus to make an attack. This was especially the case in attempting to produce lemon-spot. Infection at the stigma of lime blossoms is one of the inoculations most easily accomplished.

Leaf-spot is easily produced artificially on foliage infested with purple mites. To produce such an infection a leaf must be washed carefully to free it from danger of natural infection, and then spores from a pure culture should be applied to the epidermis, after which a moist atmosphere is necessary.

DISTRIBUTION OF THE DISEASES.

The diseases known as wither-tip, anthracnose, leaf-spot, and canker extend through a large portion of Florida, the West Indies, South America, Australia, and Malta, and it seems probable that they occur

in all parts of the world where the orange is cultivated, especially in the more humid regions. The drier regions are more exempt from leaf and branch inhabiting fungi.

In Florida the diseases seem to be increasing in severity. Prof. L. M. Underwood[a] wrote, in 1891:

> This disease [wither-tip] was found at only one point in Lake County. Dr. Martin found it in 1886 at Green Cove Spring. It does not seem to be widespread nor at present of much importance, but is recorded here that attention may be called to it, so that its nature may be known and its progress watched.

Professor Hume[b] has collected specimens of the disease in several places in Florida. He also mentions that some pomelo seedlings lost nearly all of their leaves as a result of the attack of the fungus in question.

Miss Stoneman[c] found that this fungus attacked orange trees in conservatories.

Penzig[d] mentions this fungus as being destructive to citrous plants, attacking the foliage mainly.

McAlpine[e] found this fungus on the orange near Melbourne, Australia, in 1892, and in 1898 it was found by Troyon to be destructive to lemon leaves in Queensland.

In Brazil it seems to be quite generally distributed. Noack[f] found it especially severe at São Paulo, where it was recognized not only on the leaves, but also on the smaller twigs. The latter were killed as far as the fungus penetrated, showing a very decided demarcation between the sound and the diseased areas.

GENERAL METHOD OF ATTACK.

The initial lesion is usually at the tip (see Pl. V, fig. 1) or an edge of a leaf. More rarely is a leaf attacked at the midrib or some other interior portion. The part attacked becomes light green, then turns brown. Then the acervuli form; at first light brown, then dark brown or nearly black. They may develop on either surface and in various arrangements.

EXTENT OF INJURY.

All sizes of trees, from those located in the nursery (even seedlings in the seedling beds) to the oldest trees in a grove, are subject to attack. Budded trees less than a year old are rarely attacked except in the leaves. Where such infections are allowed to remain on the trees the diseased area extends into the growing twigs and causes the typical

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[a] Jour. Myc., VII: 35, 1891.

[b] Bul. Fla. Agr. Exp. Sta., 53: 172, 1900.

[c] Bot. Gaz., XXVI: 87, 1898.

[d] Funghi Agrumicoli, p. 66. Padova, 1882.

[e] McAlpine, D. Fungus Diseases of Citrus Trees in Australia, 102, 1899.

[f] Noack, Fritz. Zeitschrift f. Pflanzenkrank., X: 329, 1900.

"wither-tip." (See Pl. V, fig. 2.) In such cases the tip dies back for a distance, or the disease may go as far as the trunk and then stop. A bud below the diseased portion then pushes forward, but unless preventive measures are used the second sprout withers back like the first. In this way the disease may prevent the tree from making any growth, and even kill it in four or five years. (See Pl. VI.)

The initial attack in older trees is the same as in trees in the nursery rows. The fungus gains entrance to the tissues of the leaf and from this grows down into the fruiting twigs. This cuts off much of the younger growth in severe cases and thus prevents blooming to a large extent. Such cases are frequently mistaken for blight, but a more common error is to attribute the injury to die-back. It may be readily distinguished from blight by the fact that only small twigs die off, and these do so without any wilting of leaves. Even the leaves that are so badly diseased that they fall do not wilt, while in the case of blight the leaves wilt with no visible sign of injury. It may be distinguished from die-back by the absence of multiple buds, of gum pockets, or of dark excrescences. One or more of these characters always accompany die-back. Die-back twigs may be attacked by this fungus, but in such cases wither-tip must be regarded as the secondary disease. This disease may be also present in a blighted tree. Any agency that lowers the vitality of a tree, whether fertilizer, weather, or condition of soil, predisposes it to an attack of wither-tip, but trees that are in the most healthy condition possible are also attacked when exposed to infection. The damage caused by this disease is very largely overlooked from the fact that it occurs upon the smaller twigs and is often attributed to other diseases, as previously stated. Wherever pruning is practiced the infected branches are usually cut off before the nature of the disease becomes fully apparent.

VARIETIES ATTACKED.

All varieties and species of citrous trees and fruits cultivated in Florida are more or less subject to attack. Since the parts attacked and the parts most greatly damaged differ considerably, the measures adopted for relief must be varied according to the different diseased conditions.

LIME.

ANTHRACNOSE.

The lime is the most severely attacked of the citrous species. It sustains its greatest loss during the time of most rapid growth, which is usually during the spring and early summer. The effect of the fungus in the young growing shoots is somewhat peculiar, as it resembles the result of an attack from biting insects, and by many persons it is attributed to this cause. (See Pl. I, fig. 1.)

The infection usually takes place at the axil of a leaf or some other place where the spore may find lodgment, and the fungus then cuts off the stem, causing the upper part to fall over and hang lifeless beside the other portion, or it may fall away; in this manner simulating the effects of insect depredations. In such cases gum quickly forms at the wound and prevents the fungus from forcing its way down the twig.

Besides the young growing twigs and leaves, the blossoms, the unopened buds, and the young fruit are attacked. When the fungus attacks an unopened bud the latter fails to develop and the entire outer portion becomes covered with spores. In the opened blossom the most common point of attack is the stigmatic surface of the pistil. (Pl. II, fig. 1.) The fungus grows in the stigma and finally destroys the entire fruit; this, however, usually falls off before the fungus has time to penetrate below the calyx. By attacking the blossoms the fungus may render the whole tree entirely fruitless, the calyxes remaining until the normal time of ripening, giving the branch a very peculiar appearance. (See Pl. II, fig. 1, representing various stages in the development of the disease.)

In addition to attacking the open bud, the spores frequently find a place for infection in the nectaries. The development of the fungus here causes the fruit to fall, and the resulting appearance is much the same as when the infection took place in the stigma.

WITHER-TIP.

When the fungus gains entrance from the terminal bud or from leaf infection the formation of the gum previously mentioned does not take place, and the disease may extend down the twig, resulting in a case of wither-tip similar to that encountered in other species of citrus. (See Pl. I, fig. 2.)

FRUIT CANKER.

If the bloom escapes, the young fruit may be attacked at almost any subsequent period. (Pl. II, figs. 2, 3, and 4.) The attack on the young fruit frequently causes a portion to be taken out as though bitten by a grasshopper or some other gnawing insect. This causes a large percentage of the young fruit to fall. Fruits after they are about half developed are not usually attacked. When the fruit has reached considerable size (about that shown in Pl. II, fig. 4) before it has been attacked, corky tissues form and a development takes place resembling scab or verrucosis. (See Pl. IV.)

LEMON.

LEAF-SPOT AND WITHER-TIP.

Lemon leaves are attacked in the typical way, causing leaf-spot, and from these the disease extends into the twigs, causing the wither-tip. For a description of the characteristics of this attack see page 10.

LEMON-SPOT.

The disease causes the most serious damage to the mature fruit. The fungus finds entrance through some slight bruise or abrasion of the skin, or it may be that infection takes place through the uninjured skin under conditions not known at present. Attempts at artificial inoculation through the uninjured skin of the lemon failed uniformly. Even so slight an abrasion as rubbing the fruit together in a packing crate or handling it roughly gives sufficient opening for the fungus to enter. The results of applying spores from pure cultures to the epidermis confirmed this conclusion. When the fungus has once found its way into the epidermis a dark spot is produced. (See Pl. II, fig. 5.) This continues to enlarge until a definite brown spot is made. (See Pl. III, fig. 1.) The development then continues until the entire rind of the lemon is browned. Ordinarily the diseased skin hardens, so that the actual usefulness of the lemon has not been materially impaired by the attack, but since it is not salable its value has been destroyed.

The injury from this disease is the greater because of the fact that infection to a large extent occurs during the handling of the fruit, especially during the coloring period, so that the fruit is sent off to market before the disease is visible. The diseased spots continue to enlarge, and when the fruit arrives in the market they may be the size represented by the figures of Plate III. This of course makes the fruit unsalable, and it becomes necessary for the merchant to repack, discarding all fruit that shows infection. Spores are rarely produced on such lemons, except when the fruit is kept in a moist place, in which case they are produced in great profusion, as illustrated by figure 2 of Plate III.

The peculiar way in which lemons have to be handled for market makes them especially liable to attack. The fruit is picked from the tree when still green. The growers allow the lemons to mature sufficiently to develop in them a certain amount of citric acid. When they have attained the proper size (and this must be learned by experience) so that they will shrink in the course of curing to the size demanded by the market, they are picked and placed in a coloring house, or they may be placed in a large heap, which is then covered with hay or similar material to keep out the light and to keep them at a uniform temperature. It therefore happens that the lemon groves must be picked over several times during the ripening season, the largest and most fully developed specimens being taken off usually in August or September, according as experience dictates. In handling these it is almost impossible to keep them from being bruised or slightly scratched or even pricked by thorns. Such abrasions in the epidermis, however slight, are sufficient to permit the entrance of the fungus.

THE COLORING HOUSE.

The coloring houses for the lemons are small structures, usually about 12 feet wide by 14 feet long and 10 or 12 feet high. They are double walled and built with a steel roof. The sun shining on this roof causes the temperature of the building to rise. By means of ventilation at the bottom and top the cool air is allowed to enter at the floor and the hot air to pass out at the ridge of the roof. By means of these ventilators the temperature is kept from reaching too high a degree. At night the openings which permit the cold air to enter are closed, and if the outdoor temperature happens to be quite cool the ventilators in the roof are also closed. In this way the temperature of the coloring house causes a very rapid ripening of the lemons, the fruit turning yellow in a few days. The evaporation from the lemons causes the air to become humid, creating a most admirable condition for germinating any *Colletotrichum* spores that may be adhering to the fruit. Spores that happen to be near an abrased place in the epidermis of the lemon will find an entrance and produce the disease in the fruit. The drying of the fruit which occurs at the latter end of the coloring period causes the affected portions to become depressed brown areas when the disease has progressed sufficiently.

When the lemons have been permitted to mature rather fully the process in the curing house is of short duration. No matter how short it is, however, it is always sufficiently long to permit fungus infection. When the period between infection and removal of the fruit from the coloring house is of short duration, the spots have not had time to collapse and become brown, making it impossible to detect the disease when the fruit is being graded and put into crates; consequently a considerable percentage of lemons infected with *Colletotrichum* is packed and shipped to the markets and the diseased spots develop in transit.

Experiments with infected lemons show that the fungus continues to develop, even if they are placed in the dry atmosphere of a living room, and that a spot is produced, as shown in Plate III, figure 1. These spots when examined under a microscope showed no fungus spores, and only a few mycelia were found in the tissues of the lemon rind adjoining the blackened area. On lemons under normal conditions, such as those in a crate on the way to market or in a storeroom, these spots develop very rapidly. Freight cars or the holds of vessels are usually superheated, bringing the temperature up to that needed for the most rapid development of the fungus. Crates of lemons that were started out from the packing house during August, 1902, without the slightest visible speck, were found to have from 5 to 25 per cent of specked fruit when they arrived in the Boston market. Specimens taken to the laboratory and kept under conditions

similar to those of lemons packed in a crate developed spots varying in size up to three-fourths of an inch in diameter. Every lemon thus spotted is rendered worthless for commercial purposes; nor is the entire loss represented by the percentage of specked lemons, since a crate of lemons containing even a small percentage of specked fruit can not be sold except at a liberal discount or after the additional expense of repacking.

When specked lemons are placed in a moist chamber the fungus develops very rapidly and produces a great quantity of spores, as shown in Plate II, figure 2. The lemons under these conditions give out a peculiar moldy citric odor. It not infrequently happens that sufficient moisture is produced in transit to market to permit a very full development of spores. In storage especially this is true.

THE COLORING BED.

The very considerable loss sustained as the result of curing lemons in a house caused it to be suspected that the curing house was at fault in this matter. Curing beds were therefore prepared. These are made by selecting a position that is high and dry, clearing off the land, and smoothing the surface. This is then covered with hay or some other soft material. The picked lemons are placed upon this bed to a depth of a foot or more, and are covered with hay or similar material to a sufficient depth to keep out the light. In this bed the lemons go through a curing process very similar to that of the curing house. The temperature being much lower and the possibility of regulating it being removed, the process is much less certain and less satisfactory than in the curing house, the lemons not curing uniformly. In these curing beds the spotting of the lemons goes on in very much the same way as in the curing house. The time elapsing between placing the lemons in the curing bed and removing them from it is considerably longer than in the curing house; consequently a greater percentage of the lemons infected with *Colletotrichum* show spots, and the fungus has time to develop larger spots, which makes it less difficult to detect the diseased lemons. As a consequence, fewer lemons infected with the fungus pass the graders and packers, and a smaller percentage is lost after being shipped.

ORANGE AND POMELO.

LEAF-SPOT.

The first point of attack is in the leaf. The development of the fungus takes various peculiar forms. At times the acervuli are distributed in a more or less regular way from a center, resembling "fairy rings." At other times the infection takes place in the tip of the leaf, which gradually withers back to the stem. Small trees may be defoliated and the fungus continue to develop in the twigs (see Pl. V).

WITHER-TIP.

The smaller twigs of the sweet orange and pomelo are very frequently and severely attacked. In a great many cases the death of twigs from an attack of wither-tip is supposed to be the result of die-back. This may, however, be easily distinguished from die-back, as indicated on page 11. It not infrequently happens that die-back and wither-tip occur on the same twig. Any material weakening of the health of the tree is very likely to induce an infection; this, however, is not a necessary antecedent to infection. The fruit of these two varieties appears to be exempt from attack.

DESCRIPTION OF THE FUNGUS.

Acervuli located on the surface of the leaf, twig, or fruit; 90–270μ in diameter, erumpent, superficial. Shape various, not uniform, occurring on either surface of citrous leaves; disposed irregularly or in more or less concentric lines; pale to dark colored. On tender lime twigs, tender lemon twigs, lemon fruits, and lime fruits, pale colored, dull red in masses (see Pl. V), confluent. Epidermis breaks irregularly.

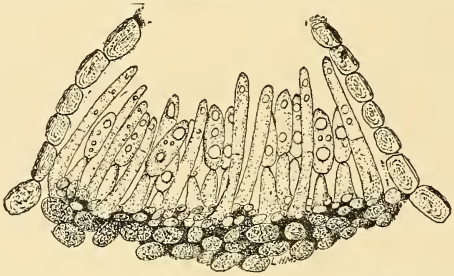

FIG. 1.—Section of acervulus. (Drawn by L. H. McCullough.)

Setæ fuliginous, ranging in length from 60 to 160μ, frequently once or twice septate, disposed at margin of acervuli. Frequently absent, and on tender lime twigs, tender lemon twigs, lemon fruits, and lime fruits usually absent.

Conidia broadly oval or oblong, 10–16μ by 5–7μ, hyaline; size variable in same acervulus, usually with one or two oil drops. Developing from a well-defined stroma; basidia, 3–18μ. In moist chamber the conidia stream from the break in the epidermis.

Intra-basidial setæ, variable 8–30μ by 3–6μ, cylindrical or sometimes enlarged at distal end; hyaline.

SYNONYMY.

Colletotrichum glœosporioides Penzig.

Vermicularia glœosporioides Penzig. Funghi Agrumicoli, No. 90, p. 66, fig. 1188, Padova, 1882.

Phyllosticta adusta, E. & M. Jour. Myc., II, p. 130, November, 1886.

Colletotrichum glœosporioides Penzig. Botanici Agrumi e sulle piante affini. Ann. d' Agria, p. 384, Plate XXXVIII, figs. 3 and 4, 1887.

Colletotrichum adustum, Ell., Jour. Myc., VII, p. 35, May, 1891.

PREVENTIVE AND REMEDIAL MEASURES.

TREATMENT TO PREVENT LEMON-SPOT.

The loss from spotting of lemons may be greatly reduced, if not entirely prevented, by spraying with fungicides, such as potassium sulphid, ammoniacal solution of copper carbonate, and Bordeaux mixture.

The particular fungicide to be used will depend on the specific form in which the disease manifests itself. For lemon-spot sulphur spray[a] may be used after the lemons have been picked.

The spraying may be done by first placing a layer of lemons one or two deep on the curing bed, then spray this thoroughly, place upon these another layer of lemons one or two deep and again spray, continuing the placing of lemons and spraying until the amount of fruit needed to fill the bed has been supplied. After this the lemons should be allowed to dry thoroughly before the cover is placed upon the bed. It is quite probable that the sulphur spray or the potassium sulphid[b] will also be helpful in the process of coloring the lemons. Sulphur spray and potassium sulphid being mild fungicides, there is no danger of producing rot by their use.

Ammoniacal solution of copper carbonate[c] may also be used to prevent spotting, but the solution should be applied to the fruit a week or ten days before picking. The spraying should be done thoroughly and care should be exercised to get the mixture on the fruit. The amount, if at all apparent, will be so small that it will not interfere with its

[a] *Preparation of sulphur spray.*—Place 30 pounds of flowers of sulphur in a wooden tub large enough to hold 25 gallons. Wet the sulphur with 3 gallons of water; stir it to form a paste. Then add 20 pounds of 98 per cent caustic soda (28 pounds should be used if the caustic soda is 70 per cent) and mix it with the sulphur paste. In a few minutes it becomes very hot, turns brown, and becomes a liquid. Stir thoroughly and add enough water to make 20 gallons. Pour off from the sediment and keep the liquid as a stock solution in a tight barrel or keg. Of this solution use 4 quarts to 50 gallons of water.

[b] Use 1 ounce of potassium sulphid to 2 gallons of water.

[c] *To prepare ammoniacal solution of copper carbonate.*—Put 3 gallons of water in a wooden or an earthen vessel, pour 3 pints of ammonia (26° B.) in this, and stir it to mix the two evenly. Take 8 ounces of copper carbonate and shake it into the ammonia water, stirring the liquid for a while. If a considerable part of the copper carbonate remains undissolved, the liquid may be left to settle; if, however, all or nearly all of the copper carbonate is dissolved, more of it should be added in the manner previously described until a considerable amount remains undissolved; then it is set aside as stated before. After the precipitate has settled, use the clear blue liquid. The undissolved copper carbonate may then be treated with more ammonia and water, fresh copper carbonate being added whenever the residue becomes less than an ounce. The solution should not be kept for more than a day or two, and when used 1 gallon should be diluted with 15 or 20 gallons of water.

selling quality. Bordeaux mixture can not be used to good advantage on lemons, because it adheres very tenaciously to the fruit, and so reduces its selling value.

TREATMENT OF LIME TREES.

During the past year experiments performed by Mr. M. S. Burbank, of Cocoanut Grove, Fla., at the Red Mill fruit farm, with a view to protecting lime trees from the attacks of this fungus, brought out some interesting results. One tree under observation had been producing limes for a number of years in a most prolific manner, but during the three years preceding 1902 the crop had been a total failure, owing to the attacks of *Colletotrichum glœosporioides*. Spraying with Bordeaux mixture [a] was begun in September, 1902, and was continued at intervals as thought advisable, and in less than a year the disease had been almost entirely subdued and the tree bore a heavy crop of fruit. Other trees were also treated, as well as trees in other groves, with good results.

THE EFFECT OF PRUNING.

In a small orchard, or in the case of an isolated tree, especially in a young orchard, much good can be done by cutting out diseased twigs and picking off the diseased leaves. Where this is practiced with thoroughness the disease can be reduced to a point where it does only a small amount of damage, or it may be eradicated; but pruning and picking must be done at frequent intervals and very thoroughly. This would probably be an effective method of keeping the fungus under control in the case of small orange and pomelo orchards.

Where pruning is practiced the weak limbs are taken out. The spurs that have dropped their leaves are also cut out, and in this way much of the hold-over wither-tip is removed. All wood that has withered is also taken away. This pruning reduces in a large measure the number of spores left in the grove and hence greatly diminishes the extent of the infection.

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[a] Bordeaux mixture may be prepared by dissolving 6 pounds of copper sulphate (blue stone) in 25 gallons of water. If the powdered copper sulphate be used, it may be dissolved in an hour or so by suspending it in a feed sack just under the surface of the water. In another vessel, slake 4 or 5 pounds of lime in a small quantity of water. When slaked, dilute to 25 gallons. Strain through coarse sacking into a 50-gallon barrel, to remove all the matter that might clog the nozzle of the spraying machine. Pour the copper-sulphate solution into the lime solution, stirring the mixture vigorously during the process and for two or three minutes afterward. During the stirring the paddle should be made to go back and forth. Use the mixture at once.

CULTIVATION AND FERTILIZATION.

Thorough cultivation and fertilization are among the effective ways of keeping the fungus from becoming established in an orchard. A properly cultivated and well-fertilized tree will produce new growth so rapidly and in such quantity that the amount of wood that is killed by the fungus and the number of leaves destroyed will form only a small percentage of the total number of leaves and twigs present. The same number of leaves and the same quantity of twigs destroyed on a tree of only indifferent growth would form a much larger percentage and, consequently, weaken the constitution of the tree to such an extent that it would actually die before the atmospheric conditions would become adverse to the disease. Seedlings and nursery trees not carefully attended are frequently killed in this manner. (See Pl. VI.) It is thus possible for a tree that has been properly fertilized and cultivated to withstand an attack that would prove fatal to one not in the best physical condition. While it does not seem possible to render a tree proof against attack excepting by the use of fungicides, the probability of infection and the damage to the tree can be greatly reduced by putting it in the most healthy condition possible.

FERTILIZERS.

In choosing fertilizers to aid in warding off these diseases a large percentage of potash should be used in the compound. The source of potash does not seem to be important, but sulphate of potash has proved a general favorite among growers of citrous fruits.

Sulphate of ammonia is somewhat slower in acting than nitrate of soda, but gives a firmer leaf. Nitrate of soda will produce a very quick growth and a large leaf, but it is especially subject to attack from the fungus unless well balanced by a generous supply of potash. Organic ammonia in the form of dried blood, cotton-seed meal, and bone meal should not be used in combating this trouble, as it is very likely to produce die-back in addition to the softening of the wood, and so lay the tree doubly open to attack.

SUMMARY.

(1) Wither-tip was not known to exist in Florida until 1886. In 1891 it was recorded as only of passing interest, but it is now present in every citrus-growing region of the State, as well as in many citrus-growing countries. Such is the severity of the disease that many requests for advice as to remedies have come to the Department of Agriculture from extensive growers.

(2) The diseases caused by the fungus *Colletotrichum glœosporioides* Penz. manifest themselves as wither-tip on orange, pomelo, and lemon twigs; as leaf-spot on leaves of various citrous species; as anthracnose on lime blossoms, recently set limes, lime twigs, and lemon twigs; as lemon-spot on ripe lemons, and as canker of limes.

(3) On the orange and pomelo the fungus causes the most severe damage by defoliating young twigs and causing these to die, thus reducing the amount of wood that may produce bloom in the bearing trees and cutting back seriously the growth of young trees. In lemon groves the most severe damage is done to matured fruit, while in lime groves the greatest loss occurs during the blooming season, the disease often causing all the bloom to fall. Trees less severely attacked often have over 80 per cent of the fruit cankered, and consequently its market value is much reduced.

(4) Remedial measures are effective, but these must be varied to suit particular manifestations of the fungus. Wither-tip and leaf-spot are best controlled by pruning out diseased twigs and then by spraying with Bordeaux mixture. The spotting of lemon may be controlled by spraying the fruit before picking with ammoniacal solution of copper carbonate and with sulphur spray while in the coloring bed or coloring house. Canker of limes may be prevented by cutting out wither-tip before the blooming period and then by spraying with Bordeaux mixture.

PLATES.

DESCRIPTION OF PLATES.

PLATE I. Frontispiece. Fig. 1.—Anthracnose of rapidly growing lime, infected at the angle of a leaf. The further progress of the disease has been arrested by the formation of gum. (Natural size.) Fig. 2.—Wither-tip of lime twig, infected at terminal bud, the fungus continuing to grow down the twig to the larger branches.

PLATE II. Fig. 1.—Anthracnose of young lime fruits, infection occurring in the stigma. The disease has been arrested by the shedding of young fruits before the fungus had extended below the calyx, the calyx continuing to remain on the fruiting branch. (Natural size.) Figs. 2, 3, and 4 show various stages of development. Fig. 2.—A newly set lime infected on the side. (Natural size.) Fig. 3.—Further development, lime infected on the side. (Natural size.) Fig. 4.—Lime several weeks old, infected on the side. (Natural size.) Fig. 5.—Lemon-spot as it appears in most advanced cases coming from a coloring house or a coloring bed, usually showing only one point of infection. (Natural size.)

PLATE III. Fig. 1.—Lemon-spot well developed but without spores. (Natural size.) A lemon affected with this disease for ten days or perhaps a week usually arrives in the market in the condition illustrated. Fig. 2.—Lemon-spot with spores fully developed under a bell jar. (Natural size.)

PLATE IV. Limes affected with cankers. The two fruits in the middle at the left, with small cankers, are ripe, while the other limes are green. The upper lime at the right shows attacks in three places. (Natural size.)

PLATE V. Fig. 1.—Leaf-spot on orange leaf infected at tip, with the disease gradually extending to the petiole. Acervuli have formed near the tip, but no acervuli are present in the more recent extension of the browned area. (Natural size.) Fig. 2.—Wither-tip on an orange twig infected through a diseased leaf. Three tips of recent growth are dead; acervuli have formed; the earlier growth is still green but infected. (Natural size.)

PLATE VI. Orange seedling 4 years old repeatedly killed back by wither-tip, making its fourth and last effort. Last growth 13 inches. (Negative by L. H. McCullough.)

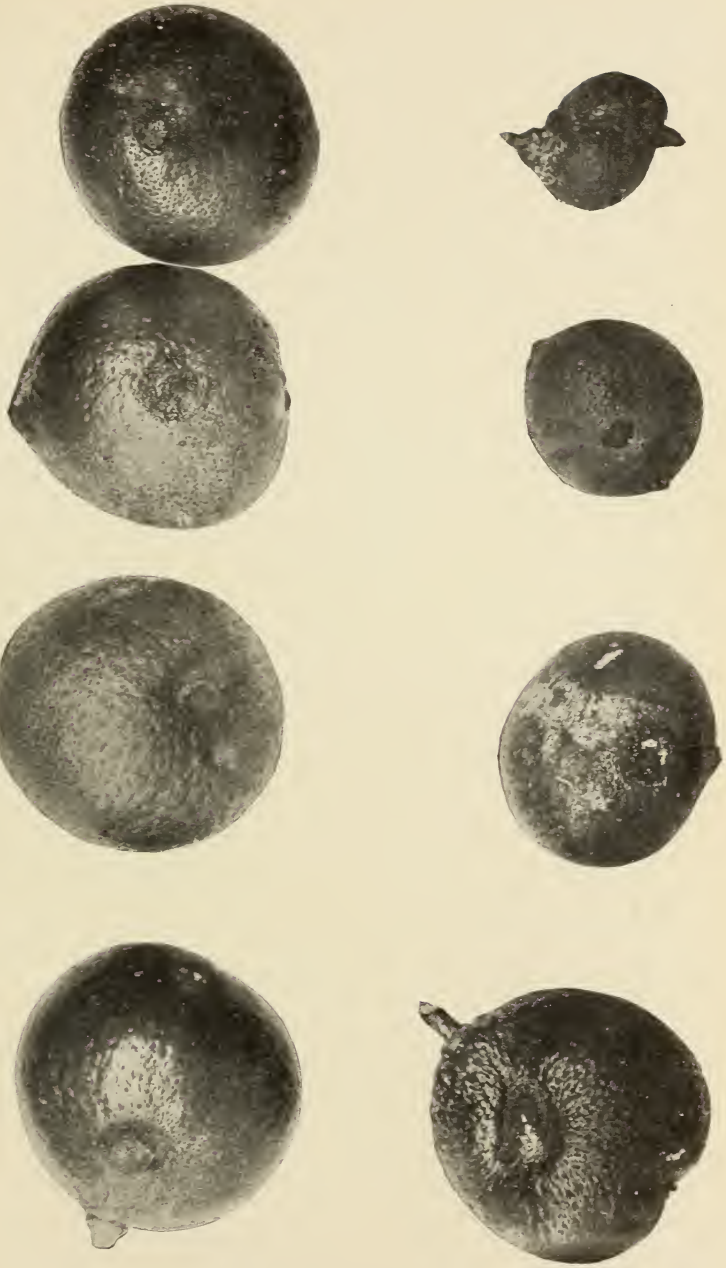
Bu. 52, Bureau of Plant Industry, U. S. Dept. of Agriculture.

FIGS. 1, 2, 3 AND 4. ANTHRACNOSE OF YOUNG LIME FRUITS.

FIG. 5. LEMON SPOT.

FIG. 1. LEMON SPOT.

FIG. 2. LEMON SPOT. SPORES DEVELOPED.



LIMES AFFECTED WITH CANKERS. NATURAL SIZE.

1

FIG. 1.—LEAF-SPOT ON ORANGE. NATURAL SIZE.

2

FIG. 2.—WITHER-TIP ON ORANGE TWIG.

SEEDLING ORANGE FOUR YEARS OLD, REPEATEDLY KILLED BACK BY WITHER-TIP.

[Continued from page 2 of cover.]

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